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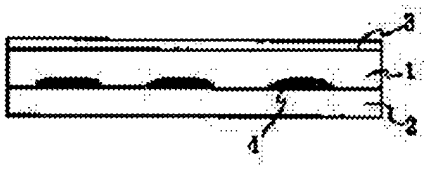
(54) HIGH-DENSITY OPTICAL RECORDING MEDIUM AND ITS PRODUCTION

(57)Abstract:

PROBLEM TO BE SOLVED: To carry high-density information by using a phase transition type optical recording material, providing this material with laminated protective layer in contact with at least one layer of its recording layer and irradiating the recording medium with a laser beam, thereby giving rise to an optical change at the boundary between the recording layer and the protective layers.



SOLUTION: The phase transition optical recording material is deposited by evaporation on a substrate by a physical or chemical vapor deposition method to form the recording layer 1. A dielectric substance having relative translucency is laminated as the lower protective layer 2 thereon. While the recording medium is subjected to auxiliary heating from the side of the lower protective layer 2, the recording medium is subjected to laser recording by bringing an optical fiber probe sharpened down to 20 nm in the opening diameter at its front end in proximity to the recording medium up to 150 nm from the side of the upper protective layer 3, by which the recording marks 4 of a radius in a range of 5 to 50 nm are formed between the recording layer 1 and the lower protective layer 2. The

recording marks of a radius 30 nm may be detected from the difference in the optical characteristics by using the same probe. The protective layers are laminated above and below the recording layer and recording signals are formed at both upper and lower boundaries, by which the information is separately carried and the higher density may be obtd.

LEGAL STATUS

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CLAIMS

[Claim(s)]
[Claim 1] The high density optical recording medium characterized by making information support with the record signal which the interface between this recording layer and this protective layer was made to generate in optical change in the optical recording medium which has a substrate and the recording layer prepared on it while carrying out the laminating of the protective layer in contact with one [at least] field of this recording layer.
[Claim 2] The high density optical recording medium according to claim 1 using what has the crystallization temperature [in / it has a protective layer up and down, and / the interface of an up protective layer and a recording layer] of a recording layer higher than the crystallization temperature in the interface of a lower protective layer and a recording layer.
[Claim 3] The high density optical recording medium according to claim 1 or 2 in the range whose magnitude d of the record signal generated in the interface of a recording layer and a protective layer is 5-50nm.
[Claim 4] The manufacture approach of the high density optical recording medium characterized by making information support by irradiating laser light at this, making the interface of a recording layer and a protective layer produce optical change using the material for optical recording which has the protective layer which carried out the laminating in contact with one [at least] field of the upper and lower sides of a substrate, the recording layer prepared on it, and a recording layer, and making a record signal form.
[Claim 5] The record playback approach of the high density optical recording medium according to claim 1 which detects the difference of the record signal which prepared the protective layer up and down and was formed in vertical both interfaces of a recording layer, or the sum, and reads information.
[Claim 6] The record playback approach of the high density optical recording medium according to claim 1 which detects the physical relationship of the upper and lower sides of the record signal which prepared the protective layer up and down and was formed in vertical both interfaces of a recording layer, detects the product or ratio of the signal, and reads information.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the record playback approach which reads the information which the high density optical recording medium which made information support with a record signal with a radius of 60nm or less, its manufacture approach, and the above-mentioned optical recording medium were made to support.
[0002]
[Description of the Prior Art] Until now, the optical recording medium has played a role of the leading role of the record medium in a highly informative society, and, recently, the optical recording medium which can carry out record playback of the information on high density at high speed has come to be widely used using an optical recording method.
[0003] The phase change method using the difference of the optical property in the amorphous state and crystallized state, for example, the difference of permeability or a reflection factor, is learned using the optical MAG method which used the interaction of the light and the MAG which are called a car or the Faraday effect as such an optical recording medium, and the alloy containing a chalcogen element, and these are mainly put in practical use already as an optical recording medium of a rewritable mold.
[0004] On the other hand, organic coloring matter is used once as the optical recording medium of a write-in method, for example, a recording layer, the heat by optical exposure decomposes coloring matter, and what is recorded using the difference of the optical property before and behind that is known. About such an optical recording medium, in order to raise the recording density with high advancement in information technology, research of DVD-R of rewritable DVD-RAM or a 1-time write-in mold etc. is done briskly.
[0005] ["Jpn.J.Appl.Phys." by which it is considered for the record medium using the optical recording technique by the phase change method to fit densification from the alloy property, and the recording density of 2.6 G bytes or 5.2 G bytes is attained in the disk of 12cm size in these optical recording media using this, the 35th volume, and the 502nd page (1996) --] .
[0006] moreover, ["Jpn.J.Appl.Phys." as which the optical recording technique which was changed to the crystallized state since the AZUDEPO condition was amorphous, used the difference of the optical property using phase change mold record film, and attained densification further is also proposed, the 35th volume, and the 443rd page (1996) --] . Although this optical recording technique is what used approaching space optical recording and it has succeeded in forming the crystal mark of magnitude with a radius of 60-200nm, the grain size of phase change mold record film 60nm or less is not obtained. And in this optical recording method, although high activation energy is needed in order to make the crystal of GeSbTe form from the AZUDEPO condition that a random condition is large, sufficient record power to realize it was not able to be generated.
[0007] In addition, using the atomic force microscope, record to phase change mold record film is tried, charge distribution was produced with shot key contact on ["Jpn.J.Appl.Phys.", the 36th volume and the 523rd page (1997)], this record film, and the chromium coating head of an atomic force microscope, and

it has succeeded in record of a mark with a diameter of about 10nm. However, since the head of an atomic force microscope is used in this case, playback of that record is impossible.
[0008] Thus, in the method which uses light, records information and is reproduced, the optical recording approach and optical recording medium which record a mark with a radius of 60nm or less, and can be reproduced are not found out until now, and the technique in which it is an optical recording method and the densification more than TERABAITO can be attained is not put in practical use.
[0009]
[Problem(s) to be Solved by the Invention] This invention is the basis of such a situation and is made for the purpose of offering the approach of reading the information which the high density optical recording medium which made information support, its manufacture approach, and this optical recording medium were made to support, and reproducing record with a record signal with a radius of 60nm or less.
[0010]
[Means for Solving the Problem] this invention persons use the material for optical recording which comes to prepare a protective layer in one [at least] field of the upper and lower sides of the recording layer which consists of a phase change mold record ingredient as a result of repeating research wholeheartedly about a high density optical recording medium. If laser light is irradiated at this and the interface of a recording layer and a protective layer is made to produce optical change A record signal with a radius of about 5-50nm is formed, and a desired high density optical recording medium is obtained, Moreover, based on a header and this knowledge, it came to complete this invention for the ability of information to be reproduced easily by preparing a protective layer up and down and detecting the difference, the sum, product, or ratio of those record signals in the optical recording medium of a recording layer which made the record signal form in vertical both interfaces.
[0011] Namely, in the optical recording medium which has a substrate and the recording layer prepared on it, while this invention carries out the laminating of the protective layer in contact with one [at least] field of this recording layer The high density optical recording medium characterized by making the interface between this recording layer and this protective layer support information with the record signal generated in optical change, And [whether the difference of the record signal which prepared the protective layer up and down and was formed in vertical both interfaces of a recording layer, or the sum is detected, and information is read, and] Or the record playback approach of the above-mentioned high density optical recording medium which detects the physical relationship of the upper and lower sides of the record signal formed in vertical both interfaces, detects the product or ratio of the signal, and reads information is offered.
[0012] Moreover, said high density optical recording medium can be manufactured by irradiating laser light at this, making the interface of a recording layer and a protective layer produce optical change using the material for optical recording which has the protective layer which carried out the laminating in contact with one [at least] field of the upper and lower sides of a substrate, the recording layer prepared on it, and a recording layer, making a record signal form, and making information support, if this invention approach is followed.
[0013]
[Embodiment of the Invention] The high density optical recording medium of this invention makes information support using the material for optical recording which has the protective layer which carried out the laminating in contact with one [at least] field of the upper and lower sides of the recording layer which consists of a substrate and a phase change mold record ingredient prepared on it, and this recording layer.
[0014] About the above-mentioned substrate, as long as a front face is smooth, there is no limit and it can use transparence and opaque all. An aluminum substrate, a GaAs substrate, etc. are mentioned to what prepared the photo-setting resin layer as such a substrate on plastic plates, such as what is commonly used as a substrate of a phase change mold record medium conventionally, for example, polypropylene, acrylic resin, a polycarbonate, styrene resin, and vinyl chloride system resin, the glass substrate, or the glass substrate, and a pan. As for surface average-of-roughness-height Ra of these substrates, it is desirable that it is within the limits of 5nm.

[0015] There is especially no limit also about the phase change mold record ingredient which constitutes the recording layer prepared on these substrates, what was conventionally used as a recording layer, for example, the germanium-Sb-Te alloy generally used widely, an Ag-In-Sb-Te alloy with lower crystallization energy, and a crystallization rate can be controlled, and the Ag-In-Sb-Te-V alloy which can check crystal growth can be used.
[0016] This recording layer can be formed on a substrate using said phase change mold record ingredient with physical vapor deposition, such as a well-known approach, for example, vacuum deposition, and sputtering, or chemical vapor deposition. Under the present circumstances, said alloy itself may be vapor-deposited as a target, each component of an alloy may be vapor-deposited as a target, and you may alloy on a substrate.
[0017] In this invention, although the laminating of the protective layer is carried out in contact with the top face of the recording layer formed by doing in this way, an inferior surface of tongue, or its both sides, the layer which consists of a dielectric which is comparatively easy to penetrate light as this protective layer is suitable.
[0018] After making a crystallized state once carry out phase stabilization of the so-called thing of the AZUDEPO condition immediately after membrane formation, and the recording layer which formed membranes on the substrate from the AZUDEPO condition that a random condition is large, with light or heat as a recording layer in this invention, the thing in which irradiated laser light again, or carried out the temperature up to more than the melting point of a recording layer, subsequently cooled by ultra high-speed with heating, and the amorphous state was made to form is used. In the recording layer of such an amorphous state, the activation energy is about 1.4-1.7eV in a germanium-Sb-Te alloy recording layer, and crystal transition temperature is about 120-130 degrees C.
[0019] Although the record layer thickness in this invention is usually chosen in 10-60nm, there is especially no limit. Moreover, since it is necessary to make optical power as small as possible in order to record high density more, it is advantageous to carry out auxiliary heating from substrate back or a side face using a fill-in flash or an auxiliary heater to temperature lower about 20-30 degrees C than the crystallization temperature of a recording layer. In this invention, although what has the softening temperature or the melting point more than the melting point of this recording layer is used as an ingredient of the protective layer which carries out a laminating in contact with one [at least] field of this recording layer and that presentation does not have especially a limit, dielectrics, such as an ingredient with the good conductivity of heat especially SiN, and SiO2, are suitable.
[0020] Furthermore, in this invention, this metal layer can be made to be able to conduct the heat produced when a thin metal layer was made to form between a substrate and this protective layer and a record mark formed in it through a protective layer, and the cooling effect can also be raised. The thickness of this metal layer is about 10-30nm. If this metal layer is too thick, light cannot be inputted through a substrate but the sensibility which can detect the optical head which senses the approaching space put on right above [recording layer] or right above [protective layer] on a recording layer will fall. The protection layer thickness prepared in the bottom of a recording layer on the other hand has the desirable range of 20-300nm, in order to prevent deforming a substrate with the heat generated from a recording layer. If it denaturalizes with heat in less than 20nm when this thickness uses a plastic plate, record becomes incorrectness and it exceeds 300nm, the effectiveness by interference of light will show up as a noise on an approaching space readout head, and will reduce a signal strength ratio. Moreover, if the protection layer thickness prepared on a recording layer has desirable 500nm or less and this thickness exceeds 500nm, spacing of a recording layer and a head will be expanded, the reinforcement of the approaching space (EBANESSENTO place) to generate will decline exponentially, and signal strength will fall.
[0021] In this invention, although a high density optical recording medium is manufactured by irradiating laser light at this, making the interface of a recording layer and a protective layer produce optical change using the material for optical recording of such a configuration, making a record signal form, and making information support, in order to make a record signal form in the interface of a recording layer and a protective layer, it is required to make magnitude of a record spot into about

several nm. For that purpose, minute light opening below the light wave length who uses must be made to approach an approaching space field. It is formed by using the optical fiber which outgoing radiation opening of the waveguide which introduces light was minimum-ized [optical fiber] below on wavelength, or radicalized the tip in nano meter size for such minute light opening.
[0022] And when using an optical fiber, that by which coating of a metal, for example, gold, silver, aluminum, or these alloys was carried out to the point by the thickness of hundreds of nm may be used. The laser light source is connected to this optical fiber, and the signal generation equipment in which light modulation is possible is connected. And the piezo-electric element of three dimensions can be connected with the point of a fiber, and a location can be controlled by precision of NANOMETA. The optical fiber which is made to generate this optical contiguity place, or reads this is installed in the recording layer side of an optical recording medium, and is introduced into a part of recording layer through the protective layer in which the laser signal was formed on direct or a recording layer. Thus, the light energy of the introduced diameter of NANOMETA forms the crystal or crystalline nucleus of nano meter size with the heat generated by light or its absorption in the interface of the recording layer of an amorphous state, and a protective layer.
[0023] In this invention, a protective layer is prepared in vertical both sides of said recording layer, it is the stress relation produced between a protective layer and a recording layer, and the crystallization temperature in an interface can be changed, respectively. Especially, by the lower interface, the stress of a lower protective layer is adjusted so that it may become tensile stress to the recording layer interface side which touches this protective layer. On the other hand, in an up interface If the stress of an up protective layer is adjusted so that it may become compressive stress to the recording layer interface side which touches this protective layer Since the crystallization temperature in an up interface becomes higher than the crystallization temperature in a lower interface and can record a separate signal on an up interface and a lower interface, recording density 2-double-improves to a pan, and is advantageous to it.
[0024] Since absorb the heat held at the recording layer, without being cooled, and crystal growth is produced around this crystalline nucleus, consequently a record mark continues growth to stable size at once and a mark 60nm or more is formed immediately after the record mark which consists only of a crystal or a crystalline nucleus forms when the diameter of opening of said optical-fiber point is too large, it becomes unrecordable [TERABAITO]. Moreover, when the diameter of opening of an optical fiber is too small, the laser power of writing falls and formation of a crystalline nucleus decreases remarkably. Therefore, the magnitude of the diameter of opening of an optical fiber has desirable about 10-50nm for a diameter.
[0025] Thus, since magnitude d of this record signal is about 5-50nm, it can make high density support information in this case in this invention, although information can be made to support by irradiating laser light at a recording layer and making a crystal or a crystalline nucleus form in the interface of a recording layer and a protective layer as a record signal.
[0026] On the other hand, informational playback carries out incidence of the feeble laser light from the opposite side of the recording layer in said optical recording medium, makes a recording layer penetrate, and is performed by reading the difference of the optical property of the crystal or crystalline nucleus in the interface of this recording layer and a protective layer, and the amorphous section of the perimeter, for example, the difference of the reflection factor accompanying refractive-index change, or permeability. The readout of the difference of this optical property can form a photodetector in the edge which introduced the laser light of said optical-fiber head, for example, can synchronize the migration location and signal strength of a head, and can be performed by reading an informational write-in location and an informational signal.
[0027] Moreover, a protective layer can be prepared in vertical both sides of a recording layer, the stress of both interfaces can be adjusted, and this record signal can be separately read in the optical recording medium which made the record signal form in vertical both interfaces, respectively. In this case, it is desirable to detect the physical relationship of the upper and lower sides of the record signal which detected the difference or the sum of those record signals, and read, or was formed in vertical both interfaces, and to read by detecting the product or ratio of that signal. In the record which took the

physical relationship of a vertical record signal into consideration especially, improvement in higher recording density is expectable.
[0028]
[Effect of the Invention] The high density optical recording medium of this invention carries out the laminating of the protective layer in contact with one [at least] field of a recording layer, and magnitude makes a record signal 50nm or less form in the interface of this recording layer and a protective layer, and makes it support information to high density. Densification especially of the thing of a recording layer which the laminating of the protective layer was carried out [thing] up and down, made the record signal form in vertical both interfaces, and made information support separately can be carried out further. Moreover, according to the record playback approach of this invention, information can be easily read from said high density optical recording medium.
[0029]
[Example] Next, although an example explains this invention to a detail further, this invention is not limited at all by these examples.
[0030] After forming a SiN layer with a thickness of 100nm on a glass substrate (5nm of surface averages of roughness height) with a thickness [with a sufficient example 1 flat-surface precision] of 1mm, the recording layer which consists of a GeSbTe (atomic ratio 2:2:5) alloy with a thickness of 50nm was formed, the SiN layer with a thickness of 20nm was further formed on this, and the optical recording medium was produced. Vacuum membrane formation equipment performed these actuation continuously altogether. The pressure of membrane formation was set to 0.5Pa, and the SiN layer introduced an argon and nitrogen gas using Si target, and formed membranes by the reactive-sputtering method. The refractive index of the SiN layer in this case was 1.9.
[0031] When the crystallization temperature of the recording layer in the sample produced on the same conditions as the above-mentioned optical recording medium on the other hand was measured optically, two crystallization temperature, 185 degrees C and 196 degrees C, was observed. When the source location of this crystallization temperature was investigated in the detail, the crystallization temperature of 185 degrees C was produced in the interface of an up protective layer and a recording layer, and producing the crystallization temperature of 196 degrees C in the interface of a lower protective layer and a recording layer was checked. Drawing 1 is a graph which shows the relation between the temperature of this example, and the rate of change of transparency.
[0032] Next, irradiating the semiconductor laser light which has the wavelength of 680nm of 3.5mW for the purpose of heating assistance from the glass substrate side of said optical recording medium at a recording layer, from the up protective layer side of this optical recording medium, the diameter of opening of the point which coated Au with the thickness of 100nm made the fiber probe which is 20nm approach to 150nm, and recorded the signal using 200mW Ar-ion-laser light. Under the present circumstances, the probe was made to scan by 20micrometers/second in rate, and the signal was modulated by 1kHz.
[0033] Subsequently, semiconductor laser light with the wavelength of 680nm of 1.0mW was irradiated from the opposite side of a recording layer, said probe was set by the exposure shaft of this laser light, the probe was made to approach to 150nm at a record medium, and when the recorded part was read, the signal with a radius of 30nm was detectable.
[0034] Next, when the record medium which recorded the signal was destroyed and the recording layer was observed with the transmission electron microscope and the atomic force microscope, it was checked that the record mark is formed in an interface with a lower protective layer. It is the mimetic diagram showing the condition that the record mark was formed in the interface of a recording layer and a protective layer by this example, and, as for drawing 2 , it turns out that the record mark 4 is formed in the interface of a recording layer 1 and the lower protective layer 2. In addition, 3 is an up protective layer.
[0035] After forming SiO two-layer with a thickness of 20nm on a glass substrate with a thickness [with a sufficient example 2 flat-surface precision] of 1mm, the recording layer which consists of a GeSbTe (atomic ratio 2:2:5) alloy with a thickness of 50nm was formed, the SiN layer with a thickness

of 100nm was further formed on this, and the optical recording medium was produced. Vacuum membrane formation equipment performed these actuation continuously altogether. The pressure of membrane formation was set to 0.5Pa, the SiN layer introduced an argon and nitrogen gas using Si target, and SiO two-layer introduced an argon and oxygen gas using Si target, and formed membranes by the reactive-sputtering method.

[0036] When the crystallization temperature of the recording layer in the sample produced on the same conditions as the above-mentioned optical recording medium on the other hand was measured optically, two crystallization temperature, 170 degrees C and 185 degrees C, was observed. When the source location of this crystallization temperature was investigated in the detail, the crystallization temperature of 185 degrees C was produced in the interface of an up protective layer and a recording layer, and producing the crystallization temperature of 170 degrees C in the interface of a lower protective layer and a recording layer was checked.

[0037] Next, while irradiating the semiconductor laser light which has the wavelength of 680nm of 3.5mW for the purpose of heating assistance from the glass substrate side of said optical recording medium at the recording layer, from the up protective layer side of this optical recording medium, the diameter of opening of the point which coated Au with the thickness of 100nm brought close the fiber probe which is 20nm to 150nm, and recorded the signal using 200mW Ar-ion-laser light. Under the present circumstances, the probe was made to scan by 20micrometers/second in rate, and the signal was modulated by 1kHz.

[0038] Then, the diameter of opening of the point which coated said Au with the thickness of 100nm brought close the fiber probe which is 20nm to 200nm, and recorded the signal again using 220mW Ar-ion-laser light. Under the present circumstances, the probe was made to scan by 20micrometers/second in rate, and the signal was modulated by 3kHz.

[0039] Subsequently, semiconductor laser light with the wavelength of 680nm of 1.0mW was irradiated from the opposite side of a recording layer, said probe was set by the exposure shaft of this laser light, the probe was made to approach to 150nm at a record medium, and when the recorded part was read, the signal with a radius of 10nm and the 30nm signal were detectable to coincidence. Moreover, when the cross talk of two signals in this case was measured, it turned out that a signal is separable by -20dB or less.

[0040] Next, when the record medium which recorded the signal was destroyed and the recording layer was observed with the transmission electron microscope and the atomic force microscope, as for the record mark, it was checked that a 30nm mark is formed in an interface with a lower protective layer, and the 10nm mark is formed in an interface with an up protective layer. It is the mimetic diagram showing the condition that the record mark was formed in the interface of a recording layer and a protective layer by this example, and, as for drawing 3 R> 3, it turns out that the record mark 4 is formed in the interface of a recording layer 1 and the lower protective layer 2, and record mark 4' is formed in the interface of a recording layer 1 and the up protective layer 3.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The graph which shows the crystallization temperature of one example of the recording layer in which the protective layer was prepared up and down.
[Drawing 2] The mimetic diagram showing one in the condition that the record mark was formed in the interface of a recording layer and a protective layer.
[Drawing 3] The mimetic diagram showing the example from which the condition that the record mark was formed in the interface of a recording layer and a protective layer differs.
[Description of Notations]
1 Recording Layer
2 Lower Protective Layer
3 Up Protective Layer
4 and 4' record mark

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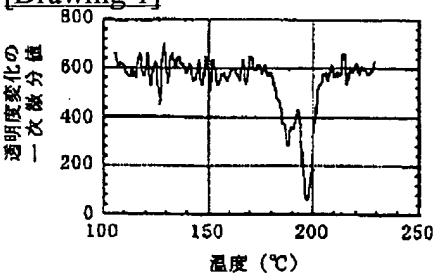
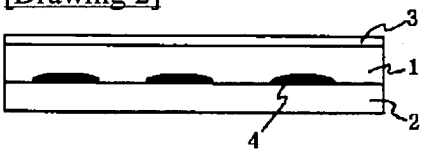
DRAWINGS

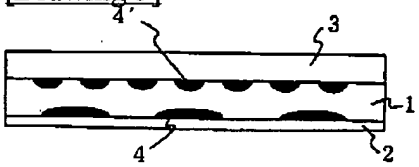
[Drawing 1]



[Drawing 2]



[Drawing 3]



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